

1                   **LONG FREE VORTEX, MULTI-COMPARTMENT SEPARATION**  
2                   **CHAMBER CYCLONE APPARATUS**

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4           This Application is of Continuation in Part Application to the  
5 Application No. 10/131425 dated 04/23/2002 when its Patent No.  
6 6596170 will be issued on July 22, 2002 now abandoned.

7           This invention relates to an apparatus for continuous  
8 separation of solid-solid, solid-fluid suspension of particulate  
9 material. More specifically, the invention is directed to  
10 considerably increasing capacity and separation efficiency as well  
11 as to reduce pressure drop compared to the conventional conical  
12 cyclone separator.

13                   **BACKGROUND**

14           An early hydrocyclone method and apparatus from U.S. Patent  
15 No. 453,105 (Bretney) issued May 28, 1891 in which there were two  
16 stages, in line, in the separating hydrocyclone. A frequent  
17 problem with this and later hydrocyclone devices are -- so called  
18 "back mix," high pressure drop and fast erosion of the conical  
19 portion.

20           A hydrocyclone is a device for creation of a free vortex, and  
21 it is the vortex that does the work in separating the particle  
22 matter form liquid.

23           The new features of the hydrocyclone air core as the vortex  
24 driving force, was discovered and used to greatly improve the

1 hydrocyclone collectors, Wlodzimierz J. Tuszko and all U.S. Patent  
2 No. 4,927,298 issued May 22, 1990. U.S. Patent No. 5,269,949  
3 issued December 14, 1993, U.S. Patent No. 5,273,647 issued December  
4 28, 1993, application Serial No. 08/238,903 filing date May 6, 1994  
5 now abandoned. Application Serial No. 08/402,175 filing date March  
6 10, 1995 now abandoned. U.S. Patent No. 6,071,424 issued June 6,  
7 2000, Application 10/131425 filed April 23, 2002

8 It is the Patent No. 6071424 and Application Serial No.  
9 10/131425 filed April 23, 2002 that generated the idea of multi-  
10 compartment separation chamber cyclone. This idea is absolutely  
11 unique from time when first Bretney's cyclone was patented. Thus,  
12 the idea of multi-compartment cyclone apparatus is obvious the  
13 intellectual property of the inventor of this Patent No. 6071424.

14 Therefore, the object of the present invention is to prevent  
15 the Patent No. 6071424 and Patent Application No. 10/131425 from  
16 infringement with claim elements omitted in these documents.

#### 17 SUMMARY OF THE INVENTION

18 This invention relates to a device for separating of  
19 particulate fluid suspension known as a cyclone separator, in which  
20 centrifugal forces of the revolving particulate suspension cause  
21 separation of the suspension into finer and coarser or light and  
22 denser fractions. The conventional of the conical predominating

1 shape, cyclone features of both high pressure drop and energy  
2 consumption to get a low separation efficiency for low capacity.  
3 This conical cyclone portion participates in creating so-called  
4 "back mix" and is vulnerable to be fast eroded.

5 To avoid those harmful phenomenons the present invention  
6 provides long-free vortex multi-compartment separation chamber  
7 cyclone with air core or without it.

#### 8 BRIEF DESCRIPTION OF THE DRAWING

9 FIG. 1 is a view of the one compartment separation chamber  
10 conventional conical cyclone.

11 FIG. 2 is a cross-section view of FIG. 1.

12 FIG. 3 is a view of plurality of cylindrical telescopic units  
13 to create multi-compartment separation chamber in cylindrical  
14 telescopic cyclone housing as Embodiment1.

15 FIG. 4 is a view of plurality of cylindrical telescopic units  
16 to create one compartment separation chamber in cylindrical  
17 telescopic cyclone housing as Embodiment2.

18 FIG. 5 is a view of plurality of cylindrical telescopic units  
19 to create multi-compartment separation chamber in conical cyclone  
20 housing as Embodiment3.

#### 21 DETAILED DESCRIPTION OF THE INVENTION

22 A conventional conical cyclone for separating of fluid

1 mixtures which are centrifugally separable is illustrated in FIG.1  
2 and FIG.2. This cyclone is comprised of short cylindrical portion  
3 1 having an inlet duct 2 for introduction of a feed suspension or  
4 feed mixture in tangential direction. An exhaust or overflow pipe  
5 3 extends through the top or ceiling wall of the cylindrical  
6 portion 1. A frustum-conical portion 4 is axially aligned with the  
7 exhaust pipe 3. In the portion 1 and 4 together as in separating  
8 chamber the feed suspension or feed mixture flows in the helical  
9 swirling flow pattern so to establish counter-flowing outer 5 and  
10 inner 6 vortexes within the separating chamber inherently causing  
11 solids in the fluid flow, which are smaller or lighter to move to  
12 the inner vortex 6 and exit through overflow pipe 3 as a smaller  
13 or lighter product stream or overflow 7. Ingredients in the fluid  
14 flow which are coarser or heavier move to the outer vortex 5 and  
15 exit through the outlet 8 as a coarser or heavier product stream or  
16 as underflow 9. Along the central hydrocyclone vertical axis to  
17 the air core 10 is created, that extends from underflow outlet 8  
18 throughout all long conical portion 4 cylindrical portion 1, and  
19 finally through the exhaust pipe 3.

20 The fundamental unit 16 of the new invented multi-compartment  
21 separation chamber comprises of two different diameter cylinders  
22 12a and 12b axially connected with passage 13 that can be of the

same material as cyclone housing or is of replaceable liners. The plurality of those fundamental units when put together axially creates multi-compartment separation chamber, so that each compartment can be seen as a separate cyclone. This multi-compartment separation chamber can be designed in cylindrical telescopic cyclone housing or in another kind of housing; for example, in a conical one.

In Figure 3 is shown a plurality of cylindrical telescopic unit when multi-compartment separation chamber is designed in cylindrical telescopic cyclone housing as Embodiment 1.

Further, the longitude axial wall section of fundamental unit is formed by two stretches -- upper one 15 and lower one 14. The upper stretch 15 creates with longitude cyclone axis the angle  $\alpha$ . The lower stretch 14 creates with cyclone longitude axis the angle  $\beta$ . The inside angle between stretches 14 and 15 is the angle  $\gamma$ .

If a given dimensions of the two cylinders and the passage are as follows:  $H+h$  - total heights of upper cylinder

$h$  - height of passage

$D_1$  - diameter of upper cylinder

$D_2$  - diameter of lower cylinder

$$\tan \alpha_{\max} = \frac{D_1 - D_2}{2(H+h)}$$

$$\tan \beta_{\max} = \frac{D_1 - D_2}{2h}$$

$$\tan \alpha_{\min} = \tan \beta_{\min}$$

then the angles  $\alpha$   $\beta$   $\gamma$  whole change extent is

$$0^\circ \leq \alpha \leq \alpha_{\max} \quad \beta_{\max} \geq \beta \geq \beta_{\min} = \alpha_{\max} \quad 180^\circ - \beta_{\min} \leq \gamma \leq 180^\circ$$

1 For situation of the angle Set No. 1 when  $\alpha = 0^\circ$  and  $\beta = \beta_{max}$

2  
3 the unit consists of the predominating upper cylindrical portion  
4 and of lower conical portion. Then, the best cyclone performances  
5 are to be achieved.

6 For situation of the angle Set No. 2 when  $\alpha = \alpha_{max}$  and  $\beta = \beta_{min}$

7  
8 the unit is of one whole conical shape. Then, the worse cyclone  
9 performances are to be achieved.

10 For situation of the angle Set. No. 3, being between Set. No.  
11 1 and Set No. 2 when  $0 < \alpha < \alpha_{max}$   $\beta_{max} > \beta > \beta_{min}$  the unit consists of two conical  
12 portions upper one and lower one. The cyclone performances are  
13 gradually worsening after the angle  $\alpha$  is growing.

14 In general case, the dimensions of all given multi-compartment  
15 separation chamber units can differ each other.

16 In FIG. 4 is shown Embodiment2 as particular case of  
17 Embodiment1. All units are of the same height dimensions and the  
18 same angle  $\alpha_{max}$  is used for each unit. Then the multi-unit  
19 separation chamber<sup>or</sup> cylindrical telescopic housing becomes one  
20 conical compartment.

21 In FIG. 5 is shown the Embodiment3 when the multi-compartment  
22 separation chamber is designed as a replaceable liners put in

1 conical housing.

2 The invention is not to be limited by the embodiment shown in  
3 the drawings or description in the specification which is given by  
4 way of example and not limitation, but only in accordance with  
5 scope of the appended claim.

6 **I CLAIM:**

7 1. In the cyclone apparatus, feed fluid comprising solid-  
8 solid, solid-fluid particulate suspension delivered in fluid flow  
9 to a cyclone separator, having an axially elongated cylindrical  
10 conical separation chamber, a cylindrical upper portion and conical  
11 bottom portion the said cylindrical upper portion having an exhaust  
12 pipe, having a bottom region disposed in said upper portion of said  
13 separation chamber and an inlet duct disposed in said upper portion  
14 of said separation chamber for introducing said feed fluid in a  
15 tangential direction in a helical swirling flowing pattern so as to  
16 establish a circular velocity and counter-flowing inner and outer  
17 vortexes within the cylindrical-conical separating chamber, a  
18 lighter portion of said feed fluid moves to the inner vortex and  
19 exits through the exhaust pipe as overflow and to a heavier portion  
20 of said feed fluid moves to the outer vortex and exist through the  
21 bottom outlet, as underflow, the improvement in the apparatus  
22 comprising the step of.: